MOSSES OF TAWHITI RAHI, POOR KNIGHTS ISLANDS, NORTHERN NEW ZEALAND

JESSICA E. BEEVER

c/o DSIR LAND RESOURCES, AUCKLAND

Abstract. An annotated list of 52 species from 23 families of mosses is provided for Tawhiti Rahi, bringing the total number of mosses known from the Poor Knights Islands to 71 species. The moss flora of Tawhiti Rahi differed significantly from that of Aorangi, the other large island in the Poor Knights group, the differences being in part attributed to the different microhabitats available on the two islands. Nevertheless, there are similarities, with 40 species in common. As on Aorangi, the moss flora of Tawhiti Rahi reflects the relatively dry climate of these low-lying offshore islands and includes a significant tropical element.

The Poor Knights Islands lie 20 km off the east coast of the North Auckland peninsula, at latitude 35° 28'S, longitude 174° 44'E (Fig. 1). They comprise two main islands (Fig. 2), Tawhiti Rahi and Aorangi, together with a number of smaller islands and islets, with a total area of 271 ha. The islands in the group are remnants of a large rhyolitic volcano, composed of hydrothermally altered lava, breccia and tuff (Wodzicki & Bowen 1979). Tawhiti Rahi (151 ha) is the largest and northernmost island of the group. Surrounded by steep cliffs rising 20-160 m above sea level, it consists of an elevated, gently rolling plateau in the north, rising to two small prominences of 190 m and 191 m respectively. The plateau is separated by rocky bluffs from the more steeply dissected southern portion of the island.

The Poor Knights Islands are the breeding ground for over 2 million sea-birds, mainly Buller's Shearwater, which breeds only on these islands (Harper 1983). As noted by Kinsky & Sibson (1959), all the 'best slopes' on Tawhiti Rahi are honeycombed with bird burrows. Although the islands were extensively modified by Maori occupation (Fraser 1925) which lasted until the 1820's (Harper 1975), and have more recently suffered occasional fires (Kinsky & Sibson 1959; Parris 1970), they retain distinctive biota, with several endemic or otherwise rare forms (see for example Oliver 1925; Watt 1982; Harper 1983; Brownsey & Jackson 1984). For this reason they remain an important Nature Reserve.

The present account of the mosses of Tawhiti Rahi is based on field work and collections made during a visit to the island from 20-27 April 1991, under the auspices of the Department of Conservation. An earlier account of the mosses of the Poor Knights Islands (Beever 1986) was based largely on my studies on Aorangi during a visit by the Offshore Islands Research Group from 27 August — 3 September 1984, with one hour only spent on Tawhiti Rahi. Records based on specimens collected by

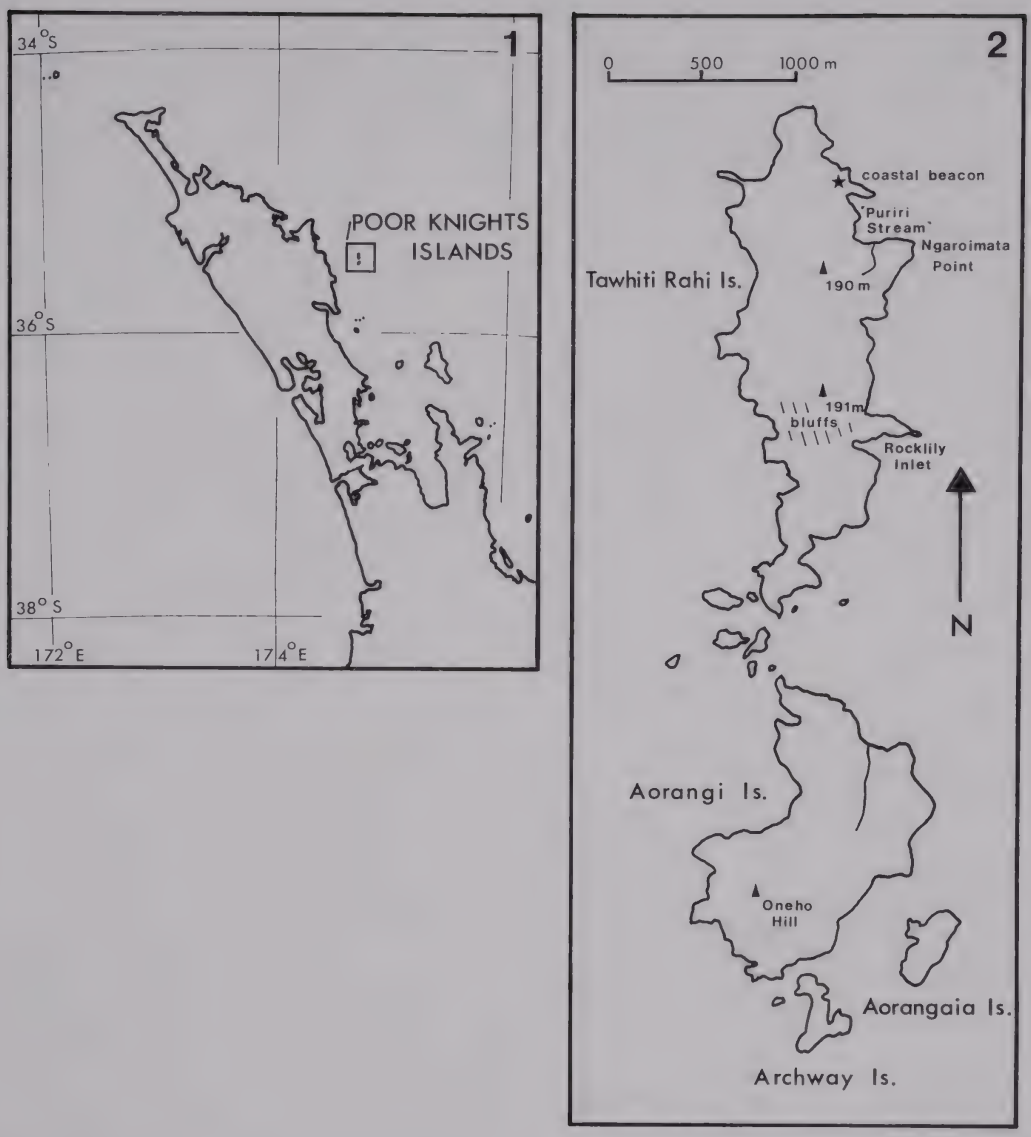

Fig. 1,2. 1. Location of Poor Knights Islands in northern New Zealand. 2. Poor Knights Islands, showing localities mentioned in the text.

A.E. Wright in 1980 and L.B. Moore and L.M. Cranwell in 1933 and 1937 were included, giving a total of 59 moss species from the Poor Knights Islands as a whole, with 13 species recorded from Tawhiti Rahi. The present account thus complements the 1984 study in its coverage of the main islands of the group. Throughout the present paper comments on the mosses of Aorangi Island are based on the data of Beever (1986).

Vascular plant vegetation of Tawhiti Rahi

Cockayne (1906), Oliver (1925) and Cranwell (1937) give brief accounts of the botany of the Poor Knights Islands. Permanent vegetation quadrats were established on Tawhiti Rahi by Parris (1970).

Most of the island is covered with forest dominated by pohutukawa (*Metrosideros excelsa*), some 6-12 m high. Over large areas the forest canopy is pure pohutukawa, but in places kanuka (*Kunzea ericoides*), tawapou (*Planchonella costata*), kohekohe (*Dysoxylum spectabile*), large-leaved milk-tree (*Streblus banksii*), and coastal maire (*Nestegis apetala*), are associate tree species, with occasional manuka (*Leptospermum scoparium*), puriri (*Vitex lucens*), tawaroa (*Beilschmiedia tawaroa*), and kauri (*Agathis australis*). On the main plateau extensive areas of pohutukawa forest have a ground cover of Poor Knights lily (*Xeronema callistemon*). The living shoots of the Poor Knights lily are raised on massive mounds of dead leaf bases. *Astelia banksii* is another very common ground plant in forest, its decayed bases often remaining as small mounds of humus after the plants have died. The southern part of the island, where fires occurred in about 1923 (Kinsky & Sibson 1959) and 1957 (Parris 1970), bears a low forest-scrubland of pohutukawa, mahoe (*Melicytus ramiflorus*), karo (*Pittosporum crassifolium*), karamu (*Coprosma macrocarpa*), karaka (*Corynocarpus laevigatus*) and Poor Knights mapou (*Myrsine divaricata*), with whau (*Entelea arborescens*) common in canopy gaps. *Astelia banksii* and the ferns *Asplenium oblongifolium*, *Phymatosorus diversifolius* and *Pyrrosia eleagnifolia* are the commonest ground plants in this area. Some ridgetop sites have suffered considerable soil erosion, leaving patches bare of vegetation. Areas of scrub are found on inland bluffs and on tops of the sea-cliffs, especially around the hanging valleys of the several intermittent streams on the island. New Zealand flax (*Phormium tenax*), karo, *Melicytus novae-zelandiae*, ngaio (*Myoporum laetum*) and taupata (*Coprosma repens*) are the dominant species in such sites. Exposed rock communities are found on inland bluffs and on the sea-cliffs. The latter are very steep and were little explored. Flax, Poor Knights lily, and *Chionochloa bromoides* are the most conspicuous plants in this habitat, with small pockets of salt meadow dominated by New Zealand iceplant (*Disphyma australe*) and glasswort (*Sarcocornia quinqueflora*).

Moss floristics

Fifty-two species of moss from 23 families were found on Tawhiti Rahi, including all 13 species previously recorded. Eleven species are new records for the Poor Knights Islands as a whole, bringing the total species for the island group to 71. (Of this total, one species, *Tortella mooreae*, has been found only on Archway Island.) Three of the new records are ruderal species, found in sites of recent human disturbance; the remaining eight are mosses of northern New Zealand coastal forests or exposed coastal rocks. Two tropical species, *Syrrhopodon armatus* and *Fissidens hyophilus*, both rarely recorded in New Zealand but known on Aorangi, were found to be locally abundant on Tawhiti Rahi, and two others which also reach the southern limits of their distribution in northern parts of New Zealand, *Macromitrium brevicaule* and *Sematophyllum homomallum*, were likewise found on Tawhiti Rahi. *Campylopus catarractilis*, recorded new to New Zealand on Aorangi, was not seen.

Major moss habitats

Nowhere on Tawhiti Rahi were mosses conspicuous, and, of 52 species recorded, 25 were rare. A wide variety of substrates, however, in forest, scrub and open communities, were occupied by mosses.

In forest and scrub, shaded rock outcrops, especially at higher altitudes and on south-facing slopes, were frequently colonised by *Racopilum convolutaceum*, *Thuidium sparsum*, *Camptochaete pulvinata*, *Fissidens hyophilus*, and swards of the minute *F. linearis*. Small stones occasionally bore *Eurhynchium muriculatum* and *Fissidens pungens*. The humus mounds formed from decomposing bases of vascular plants such as *Astelia banksii*, Poor Knights lily, *Chionochloa bromoides*, and even flax, provided a substrate for *Campylopus pyriformis*, *C. introflexus*, *Dicranoloma fasciatum*, *Isopterygium minutirameum*, *Hypnum chrysogaster*, *Sematophyllum amoenum* and *S. homomallum*. Rotten wood on the forest floor often bore *Sematophyllum amoenum*, and occasionally *Hypnum chrysogaster*. Tree bases and exposed roots were occasionally colonised by *Fissidens hyophilus*, *Thuidium sparsum* and *Hypnum chrysogaster*, and less often by *Leucobryum candidum*, *Pendulothecium punctatum* and *Zygodon intermedius*. Epiphytes on the higher parts of trees were not common: *Macromitrium gracile*, *M. prorepens*, *Hypnum chrysogaster* and *Sematophyllum homomallum* were occasional epiphytes, mainly on pohutukawa, while *Dicranoloma menziesii* and *Wijkia extenuata* were rare. Although a number of streams drain Tawhiti Rahi, all ending in hanging valleys at the top of the sea-cliffs, running water was not observed in any of them during the visit. The damp rock and soil of their beds provided, however, suitable sites for several species of mosses: *Fissidens linearis*, *Pendulothecium punctatum*, *Hypnodendron spininervium* and *Leucobryum candidum* were all locally abundant. Undisturbed soil away from water courses was less often colonised by mosses, although *Fissidens linearis* and *Isopterygium minutirameum* were recorded on this substrate. Where sea-bird burrows are dense, areas of bare soil many square metres in extent occur under the forest canopy. Soil disturbance, mechanical damage (graphically illustrated by the numerous scratches on lower leaves of Poor Knights lily plants adjacent to burrows), the toxic effect of bird droppings, and modified drainage properties may all contribute to the absence of ground plants. Occasionally colonies of the mosses *Campylopus pyriformis C. ?introflexus* and *Isopterygium minutirameum* were found on the dark reddish-brown humic loam of such sites. In some intensely burrowed areas soil erosion had resulted in extensive exposure of the roots of canopy trees, and these were in some places colonised by the mosses *Fissidens hyophilus* and *Thuidium sparsum*. *Syrropodon armatus* was seen several times where thin soil had accreted on rock outcrops adjacent to bird burrows.

In exposed sites a different assemblage of mosses was found: *Bryum campylothecium* grew on dry rock outcrops, while in small salt meadows *Tortella rubripes*, *Campylopus introflexus* and *Trichostomiopsis australasiae* were found. This last species also occurred on eroding ridgetops, together with *Bryum dichotomum*. At Ngaroimata Point, on a rock shelf topping 15 m vertical coastal cliffs, a seepage on the margins of a brackish pool contained the only well-developed plants of *Hypnodendron spininervium* seen on the island. At two exposed sites created by recent human disturbance a number of characteristic species were found. Concrete

and discarded rope at the site of the Ministry of Transport coastal beacon had been colonised by *Tortula muralis*, *Bryum argenteum*, *B. sauteri* and *B. dichotomum*, with *Ceratodon purpureus* on disturbed ground nearby. In an illegal forest clearing, 3.5 by 7 m in area, in pohutukawa forest south of Rocklily Inlet, *Funaria hygrometrica*, *Fissidens pungens* and *Bryum microerythrocarpum* were present on disturbed soil. With the exception perhaps of *Hypnodendron spininervium*, which in my experience is confined to permanently damp sites, all species recorded can apparently tolerate long periods of desiccation, and thus reflect the relatively dry climate of this low-lying offshore island.

Comparison with the moss flora of Aorangi Island

Not unexpectedly, the moss flora of Tawhiti Rahi was found to be similar to that of Aorangi, an island of similar geology, and separated by a sea-gap of only 400 m. The differences are, however, significant. Of a total of 70 species now recorded from the two islands, 40 species have been found on both. Among these 40 species some occur in significantly greater abundance on one island, and, while further exploration will undoubtedly add to the species lists, 30 mosses are at present recorded from only one island. These differences reflect to some extent the different habitats available for mosses. On Aorangi, in contrast to Tawhiti Rahi, two luxuriant bryophyte communities were found: where extensive seepages ran over exposed coastal rock platforms, and on the highest point, Oneho Hill, which at 216 m is 25 m higher than the highest point on Tawhiti Rahi. Few coastal seepages were seen on Tawhiti Rahi, and two species confined to this habitat on Aorangi, *Campylopus catarractilis* and *Bryum erythrocarpoides* (the latter recorded as *B. clavatum* and *B.* sp. undescribed), have not been recorded on Tawhiti Rahi. *Philonotis tenuis*, a rare moss on Tawhiti Rahi, was much more common on Aorangi, forming extensive clumps in the numerous coastal seepages. The habitat on Oneho Hill, where there are abundant epiphytic bryophytes and a dense carpet of moss on the ground, is unlike any seen on Tawhiti Rahi. Ten species are known on the Poor Knights Islands only from this area. *Leptostomum macrocarpum* and *Dicranoloma menziesii* were common epiphytes on Oneho Hill, while *Ptychomnion aciculare* and *Thuidium furfurosum* formed luxuriant mats on the ground. These four species were all rare on Tawhiti Rahi. The microclimatic effect of the 25 m greater elevation of Aorangi may thus be a significant factor in the development of a moss-rich community. Three species recorded only on Tawhiti Rahi were from sites of recent human disturbance, the coastal beacon and an illegal clearing, habitats not found on Aorangi. Of the other species found on only one island, three were occasional, *Ptychomitrium australe*, *Pendulothecium punctatum* and *Dicranoloma fasciatum*. These species may be found in due course on both islands, as suitable habitats appear to be present. Twelve remaining species found on only one island were rare, and there may be a chance element in their distribution.

ANNOTATED SPECIES LIST

This list includes all species of mosses that were found on Tawhiti Rahi. Species are arranged in families, listed in alphabetical order, with accession numbers of voucher specimens lodged in the herbarium of the Auckland Institute and Museum (AK). An estimate of abundance is given by the scale 'rare', 'occasional', 'common', 'abundant'. 'Locally abundant' indicates that the species was seen at few sites, but was

represented there by many individuals. The abbreviation '*C.fr.*' (*cum fructibus*) indicates that capsules were seen, 'Aorangi' that the species has been recorded on Aorangi, and 'New record' that the species is recorded for the first time from the Poor Knights Islands.

Bartramiaceae

Philonotis tenuis (Tayl.) Reichdt. AK 202180, 202181
Rare, on damp soil, shaded or exposed. Aorangi.

Brachytheciaceae

Eurhynchium muriculatum (Hook.f. & Wils.) Jaeg. AK 202125, 202157
Occasional, on rock, especially small stones, shaded. *C. fr.* Aorangi.

Rhynchostegium tenuifolium (Hedw.) Reichdt. AK 202147, 202156
Common, on soil and rock, lightly shaded. *C. fr.* Aorangi.

Bryaceae

Bryum argenteum Hedw. AK 202154
Rare, on concrete and discarded rope adjacent to the coastal beacon, exposed. Aorangi.

Bryum billardierei Schwaegr. var. *platyloma* Mohamed AK 202172
Rare, on soil and kanuka duff, shaded. *C. fr.* Aorangi.

Bryum campylothecium Tayl. AK 202158
Rare, on rock, exposed. Aorangi.

Bryum dichotomum Hedw. AK 201763, 201817
Occasional, on concrete adjacent to the coastal beacon and on soil, exposed. Aorangi.

Bryum microerythrocarpum C. Muell. & Kindb. AK 202159
Rare, on disturbed soil in anthropogenic forest clearing. New record.

Bryum sauteri B.S.G. AK 202153
Rare, on discarded rope adjacent to the coastal beacon, exposed. Aorangi.

Leptostomum macrocarpum (Hedw.) Pyl. AK 202139
Rare, on decomposing *Astelia* bases, lightly shaded. Aorangi.

Calymperaceae

Syrrhopodon armatus Mitt. AK 202160, 202179
Locally abundant, forming sheets up to 1 x 0.25 m in extent, on thin soil over rock in bird-burrowed areas, lightly shaded. Aorangi, as *S. fimbriatulus* C. Muell.

Dicranaceae

Campylopus introflexus (Hedw.) Brid. AK 201748, 202152
Occasional, on bare soil and decomposing Poor Knights lily bases, lightly shaded or exposed. Aorangi.

Campylopus pyriformis (Schultz) Brid. AK 201738, 202162
Common on decomposing Poor Knights lily bases and other humic material, and on soil in bird-burrowed areas, lightly shaded. Aorangi.

Dicranoloma fasciatum (Hedw.) Par. AK 202134, 202149
Occasional, on decomposing *Astelia* bases, lightly shaded. New record.

Dicranoloma menziesii (Hook.f. & Wils.) Par. AK 202133
Rare, epiphytic, on rock and on rotting wood, lightly shaded. Aorangi.

Leucobryum candidum (P. Beauv.) Wils. AK 202135
Occasional, on soil, tree bases and decomposing *Astelia* bases, lightly shaded. Locally abundant in the upper reaches of Puriri Stream. Aorangi.

Ditrichaceae

Ceratodon purpureus (Hedw.) Brid. AK 202151
Rare, on soil adjacent to the coastal beacon, exposed. New record.

Echinodiaceae

Echinodium umbrosum (Mitt.) Jaeg. AK 202146, 202171
Locally common on rocks in Puriri Stream, rare elsewhere on rock, shaded. Aorangi.

Fissidentaceae

Fissidens asplenioides Hedw. AK 202176
Rare, on rock, shaded. New record.

Fissidens hyophilus Mitt. AK 201699, 202124
Locally abundant, on rock, and occasional, on tree bases and exposed roots, shaded. *C. fr.* Aorangi, as *F. oblongifolius* Hook.f. & Wils.

Fissidens leptocladus C. Muell. & Rodw. AK 202174, 202177
Rare, coastal scrub, shaded. Aorangi.

Fissidens linearis Brid. var. *aeruginosus* Stone AK 202169, 202170
Locally abundant on soil and rock of Puriri Stream bed, shaded. *C. fr.* Aorangi, as *F. humilis* Dix. & Watts var. *angustifolius* Dix.

Fissidens linearis Brid. var. *linearis* AK 202163, 202175
Common, on soil and rock, sometimes in extensive swards, shaded. *C. fr.* Aorangi, as *F. humilis* Dix. & Watts var. *allisonii* Dix. & Sainsb.

Fissidens pungens C. Muell. & Hampe AK 202123, 202165
Occasional, on rock and soil, lightly shaded. *C. fr.* Aorangi.

Fissidens tenellus Hook.f. & Wils. AK 202137
Occasional, on rock, as an epiphyte, on decomposing *Astelia* bases, and on a long-dead pig's skull, lightly shaded. *C. fr.* Aorangi.

Funariaceae

Funaria hygrometrica Hedw. AK 202166
Rare, on disturbed soil in anthropogenic forest clearing. Aorangi.

Hookeriaceae

Achropyllum dentatum (Hook.f. & Wils.) Vitt & Crosby AK 202161
Occasional, on decomposing *Astelia* bases, and on soil and rock of stream beds, shaded. Aorangi.

Calyptrochaeta brownii (Dix.) J.K. Bartlett AK 202144
Occasional, on rock and exposed roots on south-facing slopes, shaded. Aorangi, as *Eriopus brownii* Dix.

Hypnaceae
Hypnum chrysogaster C. Muell. AK 202132, 202167
Occasional, on a wide variety of substrates, usually lightly shaded. *C. fr.* Aorangi.

Hypnodendraceae
Hypnodendron spininervium (Hook.) Jaeg. AK 201722, 201723
Locally abundant, on damp soil and rock in the lower reaches of several streams, and in a freshwater seepage on Ngaroimata Point, shaded or exposed. Aorangi.

Hypopterygiaceae
Hypopterygium rotulatum (Hedw.) Brid. AK 202140
Rare, on rock and rotting wood, shaded. New record.

Lembophyllaceae
Camptochaete arbuscula (Sm.) Reichdt. AK 201792, 201793
Occasional, on rock and tree bases, shaded. Aorangi, as *Camptochaete arbuscula* (Sm.) Reichdt. *sensu lato*.

Camptochaete pulvinata (Hook.f. & Wils.) Jaeg. AK 201789, 201790
Common, on rock, shaded. Aorangi.

Camptochaete ramulosa (Mitt.) Jaeg. AK 201791
Rare, on rock, near summit of the island, lightly shaded. New record.

Meteoriaceae
Papillaria crocea (Hampe) Jaeg. AK 202128
Rare, epiphytic near summit of the island, lightly shaded. Aorangi.

Neckeraceae
Pendulothecium oblongifolium (Hook.f. & Wils.) Enroth & He AK 202141
Rare, on small stone on forest floor, shaded. New record.

Pendulothecium punctatum (Hook.f. & Wils.) Enroth & He AK 202145
Occasional, on rock and exposed roots, shaded. Locally abundant on rocks in the lower reaches of Puriri Stream. New record.

Orthotrichaceae
Macromitrium brevicaule (Besch.) Broth. AK 201727
Rare, on rock in coastal scrub, lightly shaded. Aorangi, as *M. wattsii* Broth.

Macromitrium gracile (Hook.) Schwaegr. AK 202129
Occasional, epiphytic on pohutukawa and karo, and rare, on rock, lightly shaded. Not recorded by Beever (1986) on Aorangi but a specimen, CHR 398311, collected by L.B. Moore Feb. 1937, with locality 'Poor Knights Is.' is probably from that island.

Macromitrium prorepens (Hook.) Schwaegr. AK 202136, 202138
Occasional, epiphytic on pohutukawa, lightly shaded. *C. fr.* Aorangi.

Zygodon intermedius B.S.G. AK 202130
Rare, on tree base near summit of the island, lightly shaded. Aorangi.

Plagiotheciaceae
Isopterygium minutirameum (C. Muell.) Jaeg. AK 202126, 202131
Occasional, on soil, rock and humic material, lightly shaded. *C. fr.* Aorangi.

Pottiaceae
Tortella rubripes (Mitt.) Broth. AK 201690
Rare, in salt meadow 30 m above sea level, exposed. New record.

Tortula muralis Hedw. AK 202155
Rare, on concrete base of coastal beacon, exposed. *C. fr.* New record.

Trichostomiopsis australasiae Card. AK 201764, 201816
Rare, on soil, exposed. New record.

?*Trichostomum brachydontium* Bruch AK 202178
Rare, on soil in coastal scrub, lightly shaded. Aorangi.

Ptychomniaceae
Ptychomnion aciculare (Brid.) Mitt. AK 202173
Rare, on forest floor under kanuka, lightly shaded. Aorangi.

Racopilaceae
Racopilum convolutaceum (C. Muell.) Reichdt. AK 202164
Common, on rock, shaded. *C. fr.* Aorangi.

Sematophyllaceae
Sematophyllum amoenum (Hedw.) Mitt. AK 201735, 202150
Common, on rotting wood, occasional, on decomposing *Astelia* bases and other humic material, lightly shaded. *C. fr.* Aorangi.

Sematophyllum homomallum (Hampe) Broth. AK 201678, 201725
Occasional, on a wide variety of substrates. More luxuriant in high light conditions. Aorangi.

Wijkia extenuata (Brid.) Crum AK 202127
Rare, epiphytic on pohutukawa, lightly shaded. New record.

Thuidiaceae
Thuidium furfurosum (Hook.f. & Wils.) Reichdt. AK 202168
Rare, on forest floor, lightly shaded. Aorangi.

Thuidium sparsum (Hook.f. & Wils.) Jaeg. AK 201700, 202148
Common, on rock, occasional, on tree bases, exposed roots and soil, shaded. Aorangi, as *T. furfurosum* (Hook.f. & Wils.) Jaeg. var. *sparsum* (Hook.f. & Wils.) Sainsb.

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JESSICA E. BEEVER, c/o DSIR Land Resources, Private Bag, Auckland.